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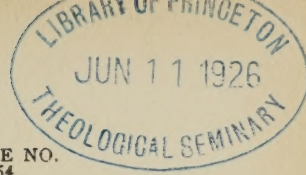
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v. 35

VOL. XXXV
NO. 3

PSYCHOLOGICAL REVIEW PUBLICATIONS

WHOLE NO.
164



Psychological Monographs

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Comprehensive Units in Learning Typewriting

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PUBLISHED FOR THE AMERICAN PSYCHOLOGICAL ASSOCIATION

By THE PSYCHOLOGICAL REVIEW COMPANY

PRINCETON, N. J.
AND ALBANY, N. Y.

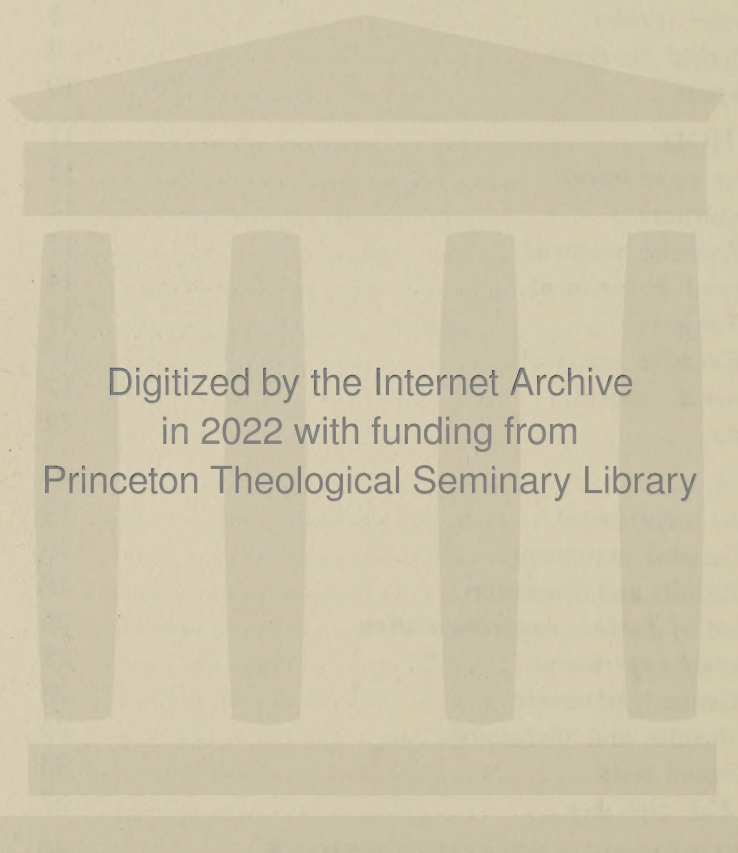
AGENTS: G. E. STECHERT & CO., LONDON (2 Star Yard, Carey St., W. C.)
LEIPZIG (Hospital St., 10); PARIS (76, rue de Rennes)

ACKNOWLEDGMENT

For inspiration and direction in the shaping of this study, my heaviest obligation is to Dr. Joseph Peterson. He also contributed greatly in the criticism of the data and manuscript form. The work of compiling the data and putting it in form was so voluminous that it could never have been accomplished in the time allotted without the helpful aid of Miss Editha Barton and Mr. W. A. Barton, daughter and son, respectively, of the writer. They gave generously of their time in this work. I am greatly indebted to Prof. H. C. Dale and the University of Idaho Administration Force for permitting me to make use of the equipment required in the main experiments run for obtaining the data here presented. I wish to make grateful acknowledgment for all this aid, without which I could never have completed this study.

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I. THE PROBLEM

General Statement.—There are two prevailing notions concerning the factors involved in learning, which seem to be fundamental in determining what shall be done in order to produce the changes known by this name. The first, and possibly the more basic, is founded on the belief in the duality of human nature; it is the idea that mind and body are essentially different and thus require treatment, in producing learning, in some ways which are not only different but are even opposite to each other. The second is the view that to repeat an act over and over again is *the law* of learning.

The first of these notions is responsible, consciously or otherwise, for statements like the following: "Learning by means of *associative memory* is a higher type of acquisition. The stimuli do not result in trial responses. Instead, the nerve impulses pass from center to center *in the brain*, arousing a succession of images and thoughts. We picture to ourselves various ways of acting; if one course of action does not solve the difficulty, we picture another, and so on till we picture some action which brings about the suitable result. Then at last the nerve impulse passes out into the appropriate motor channel and we act" (34, p. 265).¹ The other notion is responsible for much of the isolated drill that is so widely used, particularly in the acquisition of skills.

Has typewriting been properly classed in the attempts to determine the nature of the factors responsible in the acquisition of this very important skill? Is it a motor learning process of the kind consisting mostly in learning higher units of reaction, and does this process necessarily begin in the writing of letter combinations that are never found in any composition to be used after the learning has been accomplished? Is there any possibility that the successful practice of teaching reading (16, p. 300) by even

¹ References will be found at the end of the monograph.

as large units as the story (7, 111ff. and 544ff.) can be applied, in some degree at least, to the teaching of typewriting?

It seems to have been taken for granted that learning to type-write, as a matter of acquiring motor skill, should take its start in the learning of the smaller units. There is nothing, up to the time of the writer's reported experiment in 1921 (1), of an experimental or discursive kind to indicate that the nature and the size of the unit with which to begin this type of learning is even problematical. Woodworth (1921) represents the general view rather fairly when he says: "In telegraphy and typewriting, it is almost inevitable that the learner should start with the alphabet and proceed to gradually larger units" (36, p. 325). He goes on, leaving the implication that the process is just the opposite of that required in learning to read. He says further: "But in learning to talk, or to read, the process goes the other way. The child understands spoken words and phrases before breaking them up into their elementary vocal sounds; and he can better be taught to read by beginning with whole words, or even with whole sentences, than by first learning the alphabet and laboriously spelling out the words. In short, the learning process often takes its start with the higher units, and reaches the smaller elements only for the purpose of more precise control" (36, pp. 325-326).

The "piecemeal method," or the method of exercising on isolated or meaningless letter combinations, such as the first exercises proposed by J. S. Curry in 1911 (9), seems to have been taken for granted. This, and similar notions, came into vogue as a result of the introduction of the *touch system* of manipulating the machine. As long as the *sight method* was resorted to the procedure was that of either copying complete composition material or freely composing as the typewriting progressed. But the newer and better method of manipulating the machine brought with it the notion that the mastery of the keyboard and the facility of operation could best be accomplished by first learning the smaller units and then progressively larger ones, until the complex units of the entire theme seem to function rather definitely. This was done as a means of marshalling the letter, word,

phrase, and sentence units into a unit of comprehension, or a "hierarchy of psychophysical habits" (3, p. 91), which is the objective in the process of acquiring this skill.

Earlier Studies.—In 1903, E. J. Swift (31) submitted the learning of typewriting to experimental conditions, using himself as a subject and employing the *sight method*. He purposed to determine the significance of periods of no progress as shown by the plateaus found in curves of learning.

He had already had a little practice in manipulating a machine, for he says that he "had never used any kind of typewriter except to slowly finger out about a dozen short business letters two years before. It is doubtful if the number of words in all these letters exceeded five hundred" (31, p. 296). In this previous training, wherein he resorted to the *larger unit* procedure, there was clearly no attempt at a consideration of the size of unit to use in acquiring this skill. One usually resorts to the larger unit plan when learning typewriting by the sight method.

He takes note of other factors in the learning, such as the initial rise in the curve, irregularities in the shape of the curve from day to day, the "effect" of feelings of pleasure or discouragement, the differences in difficulty in the material used as copy in his practice, a comparison of his results with those found in other learning experiments. He approaches the matter with the idea that in learning to typewrite one must go from the letters to the words, and finally to the larger units. He indicates at another point in the study that possibly these factors might be made use of together. He says: "The several constituent factors that contribute to the acquisition of skill in typewriting are evidently operative together, though seemingly with varying degrees of prominence at different stages in the process" (31, p. 299). He further shows that many of the factors that condition learning operate without ever appearing above the level of consciousness.

In 1908, W. F. Book (3) made a very exhaustive study of the factors and conditions involved in the learning of typewriting. The purposes of the study were, as he states them: "(1) To obtain for each of the learners taking part in the study a practice or learning curve which should accurately represent his progress;

and (2) to obtain from his self-observations and from objective records of his writing such data as would make possible the explanation of his curves" (3, p. 7).

A very effective and complete record of all that the learners did while at the typewriter was made "by means of electrical connections between the machine and three Deprez markers writing upon a kymograph drum in such a way that everything the subject did on the machine was recorded" (3, p. 9). A switch key was attached to one of the markers and so controlled by the experimenter that the number of times the learner had to look at the copy as well as the actual amount of time spent in fixing it in memory was also recorded.

Pulse records were taken as indicators of the amount of effort being put forth as well as of the degree of attention used. These were obtained during the entire time of service by means of tambours placed on the artery in front of the ear and connected in such a way as to inscribe a pulse curve on the drum.

Careful introspections were obtained from each learner at the time of each exercise.

The learners consisted of eleven subjects differing in ability in handling a machine, from those who knew nothing about type-writing to those who had attained that degree of efficiency required for winning the medal in speed and accuracy of performance at the expositions at both Buffalo and St. Louis. Both the sight method and the touch method were used in the learning, and the exercise material was of the comprehensive kind. Two exercise sentences were used so much that they were written from memory, this for the purposes of investigating the limits of learning.

The study throughout is concerned with determining the factors conditioning learning, particularly as this process is shown in the nature of the learning curves. There is no attempt at making comparisons between the results of learning by means of units differing in size since all the learners were exercised on materials involving the more comprehensive ones. None of them was required to resort to the use of the meaningless letter combination exercise material that is so commonly found in most of the text-

books, or courses of lessons, so widely used since the touch method has been adopted.

Book confined this study to analyzing the acquisition of skill in typewriting, by both the touch and the sight methods, for the purpose of getting a better understanding of learning as it is represented by the curves that he found. The stages of learning—the letter association stage, the word association stage, and the expert stage—are investigated in an attempt to determine what conditions are necessary to produce the shift from one of these stages to each succeeding one.

There is nothing in Book's study to indicate that the nature of the material used for practice purposes could, in any way, influence the facility with which skill in typewriting is accomplished. His whole object was to understand better the acquisition of skill.

J. S. Curry (9) presented before the National Education Association in 1911 a discussion of the method known by his name. This method is well represented in its general nature by one of his early statements: "It is an old as well as a true saying that it is a safe rule of education to begin with the easy and end with the difficult, to begin with the simple and end with the complex" (9, p. 835). All of this means for him that the learning begins with the exercise of the more efficient index finger. While learning the keyboard the little finger of the left hand should be placed on *a* while exercising any other finger, while at the same time the little finger of the right hand is placed on the key for the semicolon.

He recommends the memorizing of the twelve index finger letters first. After these letters are memorized, he proposes to have them write the following exercise as a first-finger preliminary: *fgfrfbfify* repeated six times, *jhjynjujm* six times, *gfgrgvgtgb* six times, *hjhnhmhyhm* six times, and two other such groups of varying letter combinations. The second finger is exercised in the same way on letters assigned to it in many combinations. The third finger is introduced next and then comes the fourth. Mastery of these and many other such exercises, including those of every possible vowel-consonant combination, is made. This multiplicity of exercise on nonsense material is followed by the

writing of words, such as are found in the textbooks. "Sentences for speed practice should be introduced as soon as the student's knowledge of the keyboard will permit" (9, p. 838).

The following quotations indicate the extent of the practice on this kind of exercise material: "This course thus far outlined will cover about six months in a high school and two months in a business college." . . . "Practice matter should form the principal part of the work for the first year" (9, p. 838).

This shows the general attitude of touch typists concerning the kind of work to be done during the first few months of exercise. J. W. Ross, in his text (27, Preface), resorts to the isolated nonsense exercise material, but he differs from Curry in that he proposes letter combinations such as the following for the first exercises, "asdf jkl; ;lkj fdsa jkl; ;lkj fdsa jkl; ;lkj; ;fdsa," and contends that this line method "establishes an uninterrupted flow of mental direction coördinated with a corresponding smoothness in manual operation" (27). That is, up to this time those in the practical work of directing this kind of training are agreed on the matter as to the necessity of *beginning with the simple and proceeding to the complex*, but they differ as to whether mastery and facility were best accomplished by the respective "finger exercise method" or by means of "combining the letters as found in the lines" shown on the standard keyboard.

In the experiment conducted by L. B. Hill, A. E. Rejall, and E. L. Thorndike in 1913 on practice in typewriting (13) the attempt was made to determine the effects of absence from practice, physical condition of the learner, change from early to late months in the period of learning, on the rate and limits of improvement as shown by the curve of learning. Again there is no attempt to evaluate the nature of the material used in the exercise required in learning.

In 1916 F. L. Wells (35) performed an experiment in typewriting for the purpose of determining the effects of "different times of the day and different work periods, and different techniques of operation, etc., in order to increase so far as possible the efficiency of the skilled operator" (35, p. 47).

The subjects were two well trained and efficient typists, which

means that the study was little concerned with the matters involved in learning, except in so far as the determination of the kind of error, the relation of speed and accuracy, time of day as affecting performance and individual differences experienced for these two subjects would shed light on more typical learning cases.

J. C. Chapman in a study on the learning curve in typewriting (6), which was reported in 1919, took as the objects of his study, " (1) to obtain evidence with a view to a systematic study of the psychology of skill from the objective standpoint, (2) to investigate the rate of improvement of the subjects, in this particular school, using this particular method of instruction, in order to establish norms for the comparison of the relative values of different methods of investigation " (6, p. 252). The method used was that of having the learners begin with the smaller units. On this point he says: " In the touch system certain elementary habit groups have to be formed before the individual can attain a positive score at all " (6, p. 255). Owing to the conditions here expressed, he indicates that the curves of learning show nothing for the early practice, " for in the touch method, the attempt is first made to familiarize the learner with particular positions of the keyboard " (6, p. 255), in which case nothing of what the writing is like in the end can be obtained.

He points out that typewriting under high school and business college conditions lends itself well to experimentation and provides a situation that conforms to all the demands of scientific procedure. He says on this point: " Experiments on large groups found in such schools, working for long periods under normal circumstances, satisfy the conditions that have been laid down and give evidence concerning the general nature of changes in the rate of improvement in this complex function " (6, p. 252). He does not think, however, that they are equal in exactness to the results obtained under laboratory control, but adds that they are sufficiently under control to be serviceable (6, p. 252).

R. E. Hoke presented a study in 1922 of which the purposes were, first, to determine the frequency with which the various letters of the alphabet and the more common marks of punctuation are used in the English language; second, to find out the errors

in typewriting and to ascertain their causes; third, to determine the relative abilities of the two hands and the various fingers; and, fourth, by these means to determine the hand-finger loads with the thought of proposing such changes in the present keyboard as will more closely conform to the relative efficiencies of the two hands and of the respective fingers in speed and accuracy of performance.

These are all the studies on typewriting that seem available at this time. Hoke in the most recent study in this field reports what has been done as follows: "With the exception of the work by Book on *The Psychology of Skill*, little or no experimentation has been done in typewriting. Even in Book's study, the object was not so much the improvement of speed, accuracy or methods of teaching typewriting, as it was the more general aim of ascertaining, by the use of the typewriter as a mere bit of apparatus, the psychology of skill" (14).

From what is here presented of previous studies in typewriting, it is very evident that the field of this investigation—*the size and the nature of the unit to use as exercise material*—has not been cultivated; and except for the recent study of Hoke, nothing has been done to determine the effects of repetition as a factor in the determination of skill in the manipulation of a typewriter keyboard.

All of the experimentation heretofore presented on typewriting gives nothing concerning the object of this study. The field of investigation here attempted is experimentally untouched except for the incomplete study by the writer previously referred to. All discursive matter as well as all of the attempts at experimentation concerning the accomplishment of this skill, since the adoption of the touch method, seem to have just taken for granted that the formal drill approach on meaningless letter combination is the correct one.

Practical Workers.—There seems, however, to be a recent awakening among the practical workers in this field of instruction. Many of the texts are so arranged as to leave out much of the meaningless jargon as exercise material. J. W. Ross in his 1921 text (28, Preface) makes the following comments: "While the

beginning lessons of this text are based on the same fundamental principles, they have been revised and improved in the following particulars: The selection of words in each exercise is based upon frequent sequences. The writing combinations that seldom or never occur in words is reduced to a minimum, such combinations being used only to a very limited extent to impress the student with the relative positions of certain letters operated by the same finger; as *fg*, *hj*, etc. . . . The early introduction and continued use of sentences and phrases composed of frequently used words gives a variety of work that relieves the drudgery ordinarily connected with keyboard drills."

Mr. W. E. Harned (12, Preface) in his text of 1923 states: "In teaching touch typewriting it has been found that the method of repeating the same word over and over again is not only monotonous but a waste of time as well. The method of keyboard presentation set forth in 'Typewriting Studies' is (1) to teach key location by association with the guide keys, and (2) to use words of frequent occurrence, grouped from the beginning of the course in phrases and sentences."

C. E. Birch in commenting on what he calls the vocabulary method says: "Memorizing the keyboard is accomplished in a perfectly natural manner without the use of such meaningless jargon as *asdfghjkl*; or *qwertyuiop*. In their stead is introduced a most carefully graded series of simple phrases and sentences which develop skill far more surely and rapidly. The fingers are trained to find the right keys automatically, with no dependence on artificial mnemonic methods" (2, Introduction).

The text that deviates most from the formal drill idea, in what it presents for the first lessons of the learner, is the one issued by Ollie Depew in 1921. She says: "The subject is presented by the word and sentence method instead of by the 'A B C' method. Sentence writing is substituted for the harmful practice of word writing. . . . Finger gymnastics like *wxszyq*, and all other unusual combinations, have been omitted. Such exercises are useless for all practical purposes. An unnatural combination of letters will interrupt the rhythm of even a skilled writer. For the beginner such practice requires additional and

needless effort when he should be concentrating on practical material" (10, Preface).

Purpose.—It is the object of this study to determine by experimentation, under conditions as near to those of schoolroom practice as possible, the relative effectiveness of teaching this subject by the synthetic process of beginning with isolated and meaningless letter-symbol combinations and gradually going from these to the more simple words, phrases and sentences, and finally to the use of the business letter and other composition forms that are most used in the practical typing work; or *by the comprehensive process of beginning and continuing the practice on complete composition material that is most like that which the typist will be required to use when he enters upon practical service.* This study will, therefore, be a test of the validity of the statement often quoted but seldom practiced; "one should always begin by doing a thing as nearly as possible in the way it is eventually to be done" (15, pp. 66-67).

II. THE METHOD

FIRST EXPERIMENT

Subjects.—The subjects of the first experiment for group *W* (the group using the larger units from the start) ranged in age from fifteen to twenty-one years. All were of high school standing and were distributed in the classes as follows: 2 in the fourth class; 3 in the third; 6 in the second; and 2 in the first year class.

Group *P* ranged in age from fourteen to twenty-two years. The members from the respective high school classes making up this group were: fourth year, 2; third year, 4; second year, 7; and first year, 2.

The learners in group *P* were selected by the process of regular registration (Sept., 1918) in a high school where typewriting was an elective study. No student was required to take this course. All who registered for the typewriting in this group did so because they voluntarily selected it. At the time of registration nothing was said about another class to be started later. Not even the teacher in charge had any idea that such would be done.

On November the 20th notice was given that there would be another class started in typewriting. Eight students reported that they wanted to begin the work, and three of them began the practice on November 21. The rest of the eight were forced, as a result of a limited number of typewriting machines, to begin at dates ranging from November 22 to November 28. Later, three others, whose records are included in the study, were registered for this work, (Dec. 8, Jan. 3, Jan. 7, respectively). Three others attempted the work but the records were not included on account of their not being in training long enough to be of value in making comparisons.

All the subjects of this early experiment were directed by the same teacher, whose scholastic qualifications consisted of a high school course, two full years of college work, and graduation from a standard business college. She was without previous teaching experience. The only difference in the teaching of the

two groups was in the kind of material used for practice purposes and such other items of instruction and checking as were incidental to the two conditions of exercise. The members of group *W* were required to make a drawing of the keyboard on newsprint paper as a means of learning the keyboard. Aside from these differences the two groups were handled alike as far as seemed possible. The general methods of instruction used were those considered best by such a teacher as described above on just leaving a good business college.

Exercise Material.—Group *P* used the Remington Text (20) as the source of exercise material, taking the lessons in consecutive order as they are there presented. The early lessons consisted of the letters of the alphabet, marks of punctuation, and other symbols represented on the standard Remington and Underwood machines, all of these being put in meaningless combinations. The lessons became gradually more and more comprehensive until full composition was reached. The first period was used in explaining to the pupils, and directing them in such matters as the manipulations of the carriage, inserting paper, marginal stops and release, line spacing, etc. The first exercise in letter striking is made up of such letter combinations as the following: *asdfg ;lkjh asdfg ;lkjh asdfg ;lkjh asdfg ;lkjh asdfg ;lkjh asdfg*. Lesson V makes use of *asdfgertcvb ;lkjhiuyn asdfgertcvb* repeated six times for each line and continued for twenty to thirty lines.

The self-constructed charts, with the large one on the wall of which the students of both groups made use, were marked off by means of very distinct lines to indicate the respective fingers for the various sets of keys. This, together with instructions concerning the function of the different parts of the machine, was accomplished in the first period of forty minutes.

At the opening of the second practice period the pupils of group *W* were requested to follow the instructions written on the board, which read as follows: "Write a letter to Sears and Roebuck ordering a pair of shoes which should cost \$7 and should be sent by parcel post." This letter was repeated (never copied at this stage of the learning) until the pupil was tired of

it, when he was directed to write a letter to his friend inviting him to an evening party. All this early composition material was freely constructed by the learner while manipulating the machine. Never was he permitted to do copy work before he had memorized the keyboard.

This self-composed exercise material was used by group *W* until each student felt sure that he could properly produce the desired characters without the aid of the keyboard charts. From this point on in the learning, each student was required to do copy work. The copy work consisted of reading matter, taken for the most part from the Red Cross magazine materials of that time, although many of the students used their history texts or other school books as copy material, believing that by so doing they could get some help in the preparation of these lessons while doing the typewriting. There was no drill of any kind by this group on other than complete composition material.

None of the students of either group, except subject 26, had access to a machine at times other than during the forty minute period per day for five days per week during the progress of the experiment. The self-constructed keyboard charts were carried home with them and were used by some, in memorizing the keyboard.

Most all the material produced by the learners of group *W* was kept. The speed tests were the only exception to this rule. Here, as with group *P*, the time spent in practice and the records of the tests for speed and accuracy of performance were kept; but not until after they had reached the point in learning when all were working on comprehensive unit material. This means that for the first experiment complete records of all that was done, in practice, by the learners were kept only for group *W*. The nature of the exercise material used in training group *P* can be determined by consulting the Touch Method Typewriter Instructor for the Remington Typewriter 1903. The directions for the use of this text were followed by this group, for which reason it was not thought necessary to get a record of the work before the learners reached the part of the text that makes use of material comparable with that of the other group.

The results of this first experiment seemed to justify further investigation. They show big differences between the effectiveness of the two methods in the acquisition of this skill, but they were produced by the use of somewhat unsatisfactory methods. These conditions resulted in the second experiment.

SECOND EXPERIMENT

Subjects.—On January 10th an extra class for typewriting was started at the University of Idaho. This was well along toward the end of the first semester of the school year 1922–1923. Regular courses are conducted at this institution in this work, but arrangements could not be made to make experimental use of the classes regularly registered. The work of the experiment was, however, conducted in the regular typewriting room with the equipment used by the students regularly registered in such courses.

Thirty-seven students reported for work at the first meeting of the class. Each one wrote his name on a slip of paper and handed it to the one in charge. By a chance method nineteen were assigned to the larger unit group (known hereafter as group *Wa*) and eighteen were assigned to the smaller unit group (hereafter designated as group *Pa*).

On account of conditions making it impossible to get more than one period per day and also because there were only twenty-four to twenty-six machines available, it was thought necessary to handle the two groups separately and on alternate days of the week. This procedure was followed until some of the students sensed the fact that each night there were machines that were not in use, and asked that they be permitted to come more often as long as there were available machines. This was done with the understanding that no student should be deprived of his practice at his regularly assigned period. Under such an arrangement it turned out that after the first two weeks there were very few times when learners from both groups were not present at each period. This made the conditions of instruction for the two groups almost, if not quite, identical. The amount of time spent by each learner is definitely indicated in Table V below.

Of the eight males and eleven females that made up the personnel of the initial group *Wa*, four males discontinued. They were in the work only a day or two, for which reason their records are not included. Three others were later taken into this group, one on February 5th, one on February 20th, and another a day or two later. Of these three, only one remained long enough to be included in the used data. There were, then, in this group sixteen whose records are used.

In group *Pa* there were eighteen who began the work at the first session. Five of these were males and thirteen were females. Of the eighteen beginning this work seven discontinued so early that their records could not be considered. Three others were added later (February 19, 23, 27). The records of two of these are included. This leaves thirteen in group *Pa* whose records were sufficiently complete to be included.

The intelligence of each of the learners of this experiment was determined by the use of the Otis Group Test. The results of this test, the school record, the sex, and the college rank are all presented in Table V below.

Exercise Material.—After the first period, devoted to chart making and getting acquainted with the machine, group *Wa* was given the same instructions as were used for group *W*: "Write a letter to Sears and Roebuck ordering a pair of shoes," etc. In no case were they put at copy work at this stage in the learning; but were required to recompose this and other letters until the keyboard had been memorized to the point of not needing the chart as a means of locating the keys. The period of memorizing the keyboard was different in length for the various learners, but none of them required more than six periods of 55 minutes each. The large chart on the wall was marked off in such a way as to indicate the proper keys for the various fingers. This chart was kept on the wall directly in front of the class throughout the course of the experiment.

As soon as each student had learned the keyboard (at the end of about the fourth day) he was required to do copy work, using *The Vocabulary Method* text by C. E. Birch. It is claimed by the author of this text that the correspondence therein found, and

used exclusively as the exercise material in training group *Wa*, "is devoted exclusively to mastering the one thousand commonest words in the English language" (2, p. 25). The isolated word exercises found in this text were never used by any of the members of this group, but they confined themselves to writing only the full composition material included in the letter forms beginning on page 26 of this text.

After the preliminary of making a keyboard chart and getting a general understanding of how to shift the carriage, insert the paper, back space, etc., the learners of group *Pa* were required to begin work by making a study of the directions to the student given by J. W. Ross in his text of 1914, page IV. As soon as this was completed, Exercise I was assigned. After this each lesson and exercise was taken in the order presented in the text. The instructions given by the text were followed as closely as possible except that sometimes the student was permitted to take the next lesson before he had succeeded in getting the exact degree of perfection indicated by the directions. The directions of the text were deviated from only when it was thought necessary to keep the student from discouragement and from dropping the work.

This text was in use at the time in the University of Idaho. For this reason, together with the fact that the book represents the kind of material generally used in the teaching of typewriting up to 1921, this particular text was used for this part of the work. It should be kept in mind that it is the line method that is used by this text to introduce the letters into the practice of the learner.

In Ross' *Lessons in Touch Typewriting* (1914) the lessons and exercises are so arranged that the complete keyboard is not made use of until the fifteenth lesson and the ninety-second exercise is reached. The first letters used are: *asdf* for the left hand and *jkl*; for the right, in various combinations. The next two letters introduced are *r* and *u*. These are put into combination with those already exercised in both meaningless and meaningful ways. The next element brought into use is the *period*, then the letters *e* and *i*. At this point in this text we reach the end of the

sixteenth exercise and the third lesson. Some idea of the amount of work necessary to reach this point by the learner can be obtained when it is known that these early exercises consist of five lines, each containing about 48 letters and 12 spaces, each line to be written six times. If high standards of accuracy are maintained in conducting the work, the learner will be required to write the exercises many more times than is provided for by the text. Such extra standards are held to by many teachers in this work. When learners showed by their work that they were, in our experiment, making an excess of errors, they were required to meet an arbitrary standard (not more than four errors to the page) of perfection before going on to the next exercise. This standard is not provided for by the text used.

General Control.—The teaching of the two groups, in this experiment, was done by the writer and by a college student of junior standing. The writer conducted all the work up to March 23, 1923, when he was forced to leave the work in other hands. As far as the comparative treatment of the two groups is concerned, it was alike, since they were always together; *i.e.*, at every session, after the first two weeks, both groups were present, thus making the matter of teaching almost completely identical for the two groups. Very little teaching was done aside from urging subjects to speed up, to make as few errors as possible, to get ready for the speed tests, and to hand in all papers with the date and the learner's name on them. If any one of the learners was seen at any time resorting to improper positions or habits of response, he was corrected individually.

The touch method was used throughout by all groups. In no case were the results included if the learner ever resorted to the sight method in writing the speed tests. Very little of one subject's material could be included because of her unwillingness to learn by the touch system.

The periods of exercise for the 1923 groups were from 7:00 to 7:55 P.M. during each day of the week except Sunday. For the 1918-1919 groups the periods were scattered throughout the school day for five days per week.

Data.—Everything that was written by the subjects of groups *Pa* and *Wa* was made in duplicate and the original copy was handed in to the experimenter. This material consists of all the daily exercise material and the results produced in the speed tests for each student included in the study. Before handing in the sheets each time, the learner was instructed to write the date, the amount of time spent, and his name on them. They were also asked to keep a record of the number of words attempted and of the errors made. These were to be used by the students in writing up an experiment in learning as a partial requirement in a course in psychology; *i.e.*, all the subjects in both groups were doing the work for purposes of getting credit for it in psychology.

The speed tests for groups *Pa* and *Wa* were checked for the number of words and errors, first by the learner (each checking his own paper), and then verified by the experimenter and his assistants (two college students) while working under his immediate supervision. Then the number of words, and the number of letters written, as well as the number and letter placement of errors, were determined by actual count.

Nothing of the daily practice data of groups *P* and *W* is included in this study except the amount of time spent and the other general matters incident to carrying on the work. For *Pa* and *Wa* the daily exercise material is made use of. The number of times each letter was used by group *Pa* was determined by first actually counting the letters found in each of the exercises of the text used and then multiplying these numbers by the number of times each student wrote these exercises. For group *Wa* the number of words written by each student was determined by actual count. These numbers were multiplied by 5.433, the average number of letters per word for the 1,000 most common words (14, p. 12). Then by the use of the percentages, for the various letters of the alphabet used in English writing, determined by Dr. Hoke in his 1923 study (14, p. 12), the number of times each letter was used was calculated.

III. DATA

FIRST EXPERIMENT

General Statement.—The material and results presented in Table I and Table II are all that are now available for this part of this study. For the most part, only such records as are used by teachers in reporting the progress of students doing such work as typewriting were used. A strict record of the number of practice periods was kept, however, for each student. Each of these periods was of 40 minutes' duration.

The first speed test was given January 3rd. This was after group *W* had been in training for five weeks and after group *P* had been using the full composition as practice material for a period of two weeks. The speed tests for these two groups were always of ten minutes' duration. They were distributed at intervals of three weeks during the first twelve weeks, and at two weeks' interval thereafter. It should be kept in mind that group *P* began training eleven weeks earlier than any of the learners in group *W*.

The reader will note that Table II presents only words per minute for the respective measures. The reason for this is that it was the common practice for typewriting work to be evaluated in terms of a combination of words attempted and errors made. The teacher in charge used this method of evaluating and recording. The figures presented in this table indicate the number of words attempted by each student after ten words had been subtracted for each error made. In this way nothing is certain, as far as this table shows, of just how many words were written or how many errors were made by each learner.

Results and Discussion.—In Table I are presented the results and material of the first speed test (January 3rd) in another form. Here we have the actual number of words attempted and the number of errors made per minute for each learner. When these are handled in the same way that the other speed records were

handled, they give the data shown in the second column of Table II.

These two groups of learners were not very different in ability or fitness for the work of typewriting, if school marks and school rank are dependable criteria to rely upon. The school marks may be converted into figures and the distances between the several degrees may be regarded as equal. To the first decimal place there is no difference in the averages of the school marks for the

TABLE I

SHOWING THE COMPARATIVE ABILITIES OF THE SUBJECTS OF GROUP *P* AND GROUP *W* AND THE GENERAL RESULTS OF TYPING PRODUCTION OF EACH

Subject	Sex	School marks	School ranks	Total practice periods up to Jan. 3	Words attempted per min., Jan. 3	Av. errors made per min., Jan. 3	Av. words gained per practice period, Jan. 3	Total practice periods	Final score
<i>Group P</i>									
1	f	B	3 yr.	76	53.1	11.2	.70	168	49.4
2	f	B	4 yr.	81	62.2	13.3	.77	166	55.2
3	f	B	2 yr.	70	53.0	14.2	.76	169	26.3
4	m	C	2 yr.	80	47.1	8.2	.51	170	37.1
5	f	A	4 yr.	82	60.2	10.2	.73	168	56.8
6	f	C	3 yr.	73	52.1	10.7	.71	169	39.4
7	m	B	1 yr.	81	50.2	9.1	.62	170	46.6
8	m	C	1 yr.	73	48.2	11.3	.66	169	43.0
9	f	C	2 yr.	67	50.2	14.2	.75	162	20.6
10	f	B	2 yr.	68	54.3	12.1	.80	163	39.5
11	f	B	3 yr.	75	58.4	9.5	.78	167	40.6
12	f	C	2 yr.	74	55.1	10.9	.74	165	43.2
13	f	D	2 yr.	75	52.2	11.2	.70	165	34.6
14	f	C	2 yr.	76	43.3	14.3	.57	167	30.3
15	f	B	3 yr.	77	58.4	10.6	.76	168	51.8
Average		4.5	2.3 yr.	75.2	53.2	11.4	.70	167	41.0
<i>Group W</i>									
16	f	C	2 yr.	18	66.0	9.2	3.7	109	30.0
17	f	C	2 yr.	21	68.1	6.1	3.2	111	48.0
18	f	C	2 yr.	..	....	...	...	...	34.4
19	f	B	4 yr.	21	48.1	8.3	2.3	68	....
20	f	B	2 yr.	23	80.2	6.4	3.5	114	70.2
21	f	B	3 yr.	21	70.1	6.3	3.3	110	37.2
22	f	B	3 yr.	22	72.1	6.5	3.3	112	46.0
23	f	A	4 yr.	23	77.2	6.1	3.4	113	59.0
24	f	C	2 yr.	..	....	...	...	...	33.4
25	f	C	3 yr.	14	51.4	10.2	3.7	98	39.8
26	f	C	2 yr.	24	63.5	6.2	2.6	104	28.8
Average		4.5	2.6 yr.	20.8	66.3	7.4	3.2	.04	47.4

two groups and the P.E. of the difference of the average is .07.¹ In school rank, group *W* has the slight advantage of .3 of a year with a P.E. of the average difference of .0197. All subjects of both groups were without previous experience in the manipulation of a typewriter.

By consulting Table I and Table III it is seen that group *P* had been in training for an average of 75.2 practice periods, while

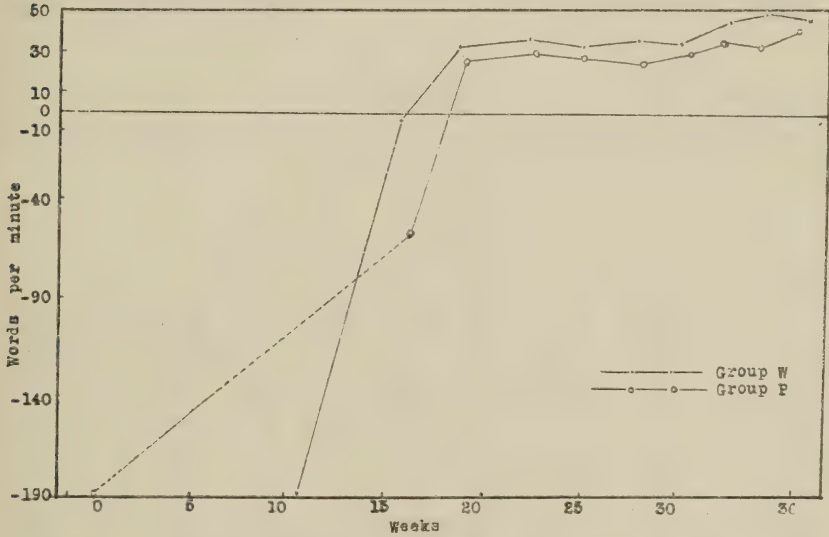


FIGURE I. Showing the average number of words written by group *P* and by group *W* after they have been penalized ten words for each error.

group *W* had been in training 20.8 periods. This is an average difference of 54.4 periods with a P.E. of this difference of 1.018. This means that group *P* had trained 3.6 times as long as group *W*.

Column 6 of Table I gives the number of words written per minute, by each learner, on January 3rd. These data were collected on the subjects of the two groups on the same day, in the same class, and on the same exercise material. In fact all speed tests were conducted alike in all these particulars for the two

¹ The letters shown in Table I and column 3 were assigned numerical values of A=6, B=5, C=4, D=3 in calculating the difference. Any other values might be used. The steps are assumed to be equal.

groups. In the number of words written we have an average difference of 13.1 words per minute with a P.E. of this average for the two groups of 2.439. The advantage is with group *W* even though it had been in training for the shorter period of time.

If we look again at the same table with a view to finding what the conditions were with respect to the accuracy with which the words were written, we see that group *P* made an average of 11.4 errors per minute, while group *W* averaged only 7.36 errors.

TABLE II
SHOWING THE NUMBER OF WORDS IN EACH OF THE SPEED TESTS FOR GROUPS
P AND *W* AFTER HAVING BEEN PENALIZED TEN WORDS
FOR EACH ERROR

<i>Group P</i>									
Words per minute in tests									
Subjects	1	2	3	4	5	6	7	8	9
1.....	-56.9	27.4	31.0	29.2	28.6	37.4	40.8	39.9	49.4
2.....	-69.8	48.3	45.8	49.8	47.4	49.6	52.7	49.3	55.2
3.....	-89.0	14.8	22.2	16.2	17.6	21.7	23.9	24.8	26.3
4.....	-34.9	22.6	25.6	23.4	18.2	25.8	27.4	30.8	37.1
5.....	-41.8	44.1	49.0	43.2	41.0	47.0	47.2	42.0	56.8
6.....	-54.9	33.4	36.6	37.4	25.2	28.6	35.6	30.8	39.4
7.....	-40.8	34.9	35.6	38.4	36.8	37.4	45.6	35.6	46.6
8.....	-64.8	33.3	29.8	29.8	24.2	17.2	37.2	31.1	43.0
9.....	-91.8	13.3	15.5	21.4	17.8	13.8	13.8	16.2	20.6
10.....	-66.7	28.9	36.2	31.0	28.4	32.1	36.2	33.1	39.5
11.....	-36.6	33.1	33.6	37.4	25.0	33.1	45.0	38.8	40.6
12.....	-53.9	30.2	21.4	21.4	20.2	33.9	29.7	23.7	43.2
13.....	-59.8	20.9	27.2	23.2	17.6	21.3	25.4	30.1	34.6
14.....	-99.7	22.1	31.2	23.1	23.2	26.3	24.2	28.8	30.3
15.....	-46.6	34.9	45.2	37.2	32.0	31.7	34.0	41.4	51.8
Average.	-60.6	29.5	32.3	30.8	26.9	30.5	34.6	33.1	41.0

<i>Group W</i>									
Words per minute in tests									
Subjects	1	2	3	4	5	6	7	8	9
16.....	-26.1	18.2	22.0	18.6	19.6	18.5	25.4	....	30.0
17.....	7.1	39.6	33.0	35.0	41.7	41.2	49.4	....	48.0
18.....	....	20.4	17.0	22.0	23.8	31.4	24.8	....	34.4
19.....	-34.9	This student would not use touch system							
20.....	16.2	50.4	69.4	45.0	60.1	56.0	66.0	55.9	70.2
21.....	7.1	28.7	24.8	30.6	32.5	29.0	32.9	43.9	37.2
22.....	7.1	32.6	32.0	32.4	29.0	32.9	40.6	57.4	46.0
23.....	16.2	45.3	52.2	52.0	48.6	45.2	61.6	60.0	59.0
24.....	....	....	....	....	....	....	....	....	33.4
25.....	-50.6	35.6	35.0	34.4	38.2	25.5	44.2	32.1	39.8
26.....	2.0	17.1	26.0	19.2	18.8	21.4	33.1	37.3	28.8
Average.	-6.2	31.9	35.7	32.1	34.6	34.6	42.0	47.8	47.4

This is a difference of 4.04 errors per minute, and the P.E. of the difference is 1.091.

If we divide the number of words written in the first speed test by the number of periods of practice up to that point in the experiment, we obtain the average number of words gained per practice period for each group. The difference in this for the two groups is 2.496 words per practice period, with a P.E. of this difference of .102. This indicates that for the time spent

TABLE III

SHOWING P.E. OF GROUP DIFFERENCES BETWEEN THE AVERAGES AND THE STANDARD DEVIATIONS OF THE DISTRIBUTIONS FOR TABLE I

	School marks	School ranks	Total practice periods up to Jan. 3	Words attempted per min., Jan. 3	Av. errors made per min., Jan. 3	Av. words per practice period, Jan. 3	Total practice periods	Final score
Averages group P..	4.5	2.3	75.2	53.2	11.4	.70	167.1	41.0
Averages group W..	4.5	2.6	20.8	66.3	7.4	3.20	104.3	47.4
Difference in averages for groups P & W	0.0	.3	54.4	13.1	4.0	2.50	62.8	6.4
P.E. of dif. in av....	.07	.02	1.02	2.44	1.09	.01	3.11	3.39
Standard deviations of distribution:								
P. ....	.23	1.1	4.5	4.98	1.8	.08	2.35	9.96
W. ....	.28	.24	2.9	10.13	1.48	.45	13.69	13.53

group *P* made on the average a gain of .704 words per practice period, while group *W* made 3.2 words.

It should be kept in mind that up to this point (January 3rd) group *P* had been in training an average of sixteen weeks, fourteen of which were on the small, or meaningless, unit material and two weeks on the complete composition material; while group *W* had been training five weeks on complete composition material from the beginning. The reason for presenting a cross section of the material at this point is to get a view of what the conditions were at a very early point in the learning after the learners had been training on material that was alike for the two groups. Up to the time that group *P* began on the complete composition material the two groups were working on different practice material, but at that point they were given the same text and the material was identical for all thereafter. In this way it was

thought possible to determine better at what point in the line of training the greatest differences were to be found. It was thought that this might help to indicate more clearly the causes for the differences shown.

Some questions must have been raised in the mind of the reader concerning the causes of the differences noted between the two groups. One such question might be: *To what extent did the learners of group W work with greater determination and zeal than in the case of group P?* Another might be: *Why are the records of some of the learners in group W not included?* Other questions might have arisen. The answer to the first one cannot be arrived at by such means as can be objectively presented; but since the members of group W began later it might be true that they did exert themselves more than usual in the ordinary practice, which was preparatory to the speed tests in which all of both groups participated with the keenest competition. However, if either group did work with keener interest, it was not observable to the teacher or the experimenter at the time.

It may be possible that the motivating factors were neither as many nor as good during the time that group P was using the *smaller unit* material, since there were no speed tests given during this time. It is a fact that most of these learners manifested "ennui" while the exercise material was of the meaningless kind. Group W also had no speed tests during the first five weeks of their work, but they showed nothing like the same degree of lack of interest that was shown by the other group. *Possibly the kind of material used is a factor in determining what the attitude of the learner will be in typewriting*, as is doubtless true also for many of the higher forms of learning.

As to the second question, it might be suggested that since the records of some of the learners were not included, the selection for typewriting skill was higher for group W. Subject 19 resorted to the sight method in her practice work so continuously that when she came to the speed tests, where she was watched by the instructor, she could not manipulate the machine any better than a beginner and would simply sit idle for most of the test period and not even try to write. She was a senior in high school but

would not follow the instructions. In this way she really had no record that would be fair to include. Case 24 was irregular at school and was not present at any of the speed tests except the last one, which left no other record that we could make use of for comparative purposes. In the single test that she took her record is relatively very good when thought of in terms of the amount of time that she spent in practice.

If we turn now to Table II and Figure 1, and attempt to determine what the difference is between the two groups after the

TABLE IV

SHOWING P.E. OF GROUP DIFFERENCES BETWEEN THE AVERAGES AND THE STANDARD DEVIATIONS OF THE DISTRIBUTIONS FOR TABLE II

Tests	1	2	3	4	5	6	7	8	9
Averages group P	-60.6	29.5	32.3	30.8	26.9	30.5	34.6	33.1	41.0
Averages group W	-6.2	31.9	37.7	32.1	34.6	34.6	43.0	47.8	47.4
Dif. in averages for groups P and W	-54.4	2.4	5.4	1.3	7.7	4.1	5.4	14.7	6.4
P.E. of dif. in av..	5.5	3.0	4.3	2.9	3.3	3.0	3.6	3.3	3.4
Standard deviations of distribution:									
P.	19.5	9.4	9.2	9.0	8.8	9.7	10.3	8.1	10.0
W.	19.5	11.3	15.9	10.7	13.1	11.0	14.0	10.6	13.5

first test, we see a very much more rapid rise in the curve of group *P* than in that of group *W*. In three weeks' time group *P* went from a minus 60.6¹ to a positive 29.5. For the same period of time, group *W* made a gain of from minus 6.2 to 31.9. How is this difference in the rate of learning to be explained? Is it possible that the eleven weeks of *formal* drill might have influenced these results?

Up to the point of the second test, group *P* used the same practice material that was used by group *W* for the period of five weeks. During the four weeks next preceding the five weeks just mentioned, it must be remembered that the material used by group *W* was first self-composed business or friendship letters until the keyboard was well memorized. This was followed by

¹ It seemed necessary to convert the first test scores to the same units that we have for the rest of the test records, by multiplying the number of errors by ten and subtracting this sum from the number of words written. This was made necessary because the remainder of the data had been so handled by the teacher in charge.

doing copy work from the current Red Cross magazines or other complete composition material most available to the student.

If we turn again to the test scores we find that the first test gives an average difference of 54.4 words per minute, with a P.E. of 5.536 for this average. After this, there is not a single difference with a P.E. that is as much as one-fourth the difference in the averages, until we get to the eighth test. Here we have an average difference in favor of group *W* of 14.7, with a P.E. of the difference of 3.25. By consulting Table II it will be seen that for this test only six of the subjects in group *W* were present. Of the three who were absent, two were relatively low in typing skill. This would have a tendency to raise the average score for this test. All the remainder are thus statistically unreliable. But the averages in each of the tests show group *W* to be superior in typing skill. Since the curves do not cross at any point—*i.e.*, all the differences are in the same direction—we have an additional assurance of the reliability of our differences. These test scores and the curves represent the speed of typing for the individuals and the groups through twenty weeks to the end of the year without any great difference represented at the end of that time. This seems to show that the two groups were nearly equal in typing skill for a rather extended period of time and probably would remain so. Was, therefore, the first period of eleven weeks of practice by group *P* a waste of time for the most part? Was this waste due primarily to the nature of the material used for practice purposes in the training?

Need of Further Experimentation.—These results, while obtained under methods of group selection and of tabulating data that are not free from scientific question, raised the problem in the mind of the writer as to the possibilities of the differences here shown being valid and explainable on the grounds of the kind of practice material used in the training of the learners. The whole problem grew up in the actual work of the writer while serving as superintendent of the school system at Elk River, Minnesota. At first there was no thought of running a control group of learners. All of the teachers of this system were, at the time, meeting regularly for the purpose of discussing the various methods for

the teaching of reading and other subjects, and there was brought up the question of the *formal* versus the *incidental* drill and also that of the unit size in learning. These discussions raised the question concerning the application to typewriting of some of the principles expressed in such quotations as the following: "One of the striking discoveries of experimental investigation is the very rapid progress in specific functions when the practicing is done on the particular connection to be established" (30, p. 159).

When we set this idea over against the opposite one, "Habits can be established only through repetition" (26, p. 73), we have a very forceful problematical situation that seemed to warrant investigation.

In the light of such work as that presented by Ebbinghaus (11), Carr (5), Cummings (8), Pechstein (21), and many others, on the size of the unit to use in learning, and that of J. C. Brown (4), Thorndike (32), Phillips (25), Kirkpatrick (17), and others, on the effect of drill, there seemed little help in an attempt to explain the results of this first experiment.

The findings in these investigations and the results of this preliminary experiment in the teaching of typewriting indicated very plainly that the learning of this act had not been sufficiently investigated to warrant any really valid results; but suggested that what had been found to be true for the learning of arithmetic, spelling, reading, and other such subjects, might not hold in this case. Under these conditions a second experiment was attempted, again under practical school room conditions, but this time using better methods of selecting the subjects for the two groups, and more uniform conditions of work for all subjects. A complete record of all that was written by each learner was kept and was made use of in working up the results.

The next two parts of this study will consist of the results of this second experiment and a statement of the conclusions based upon all the work of the two experiments.

SECOND EXPERIMENT

General Statement.—An attempt is made in presenting the results of this experiment to show records of all the materials that were produced by the learners of the two groups. It should be remembered that five of the subjects of group *Wa* and eight of

TABLE V

SHOWING THE COMPARATIVE ABILITIES OF THE SUBJECTS OF GROUP *Pa* AND GROUP *Wa* AND THE GENERAL RESULTS OF TYPING PRODUCTION OF EACH

Subjects	Sex	School marks	School ranks	Mental test scores	Total practice periods	Total letters written	Total errors made	Av. number letters per practice period at end	Final scores in letters per 5 minutes	Final scores in errors per 5 minutes	Per cent. of error in final scores
<i>Group Pa</i>											
27	f	5.5	Fr.	191	24	131,628	1,173	7.0	168	5	2.5
28	f	4.4	Fr.	137	43	226,572	3,203	8.0	343	14	4.1
29	f	4.5	Fr.	186	42	130,315	1,357	5.1	213	3	1.4
30	f	4.9	Fr.	170	17	68,946	356	7.2	123	4	3.2
31	f	4.5	Soph.	132	56	287,227	1,107	6.4	360	4	1.1
32	f	4.1	Fr.	178	34	88,041	1,171	4.7	160	7	4.4
33	f	4.5	Fr.	153	25	179,566	569	4.6	116	7	6.0
34	m	4.0	Fr.	168	51	208,183	4,665	4.2	213	8	3.8
35	f	5.6	Fr.	162	53	220,455	3,225	5.8	307	7	2.3
36	f	5.4	Fr.	147	56	164,785	3,735	6.1	339	2	0.6
37	f	4.7	Fr.	148	17	92,910	321	11.6	188	3	1.6
38	m	4.1	Soph.	165	54	274,022	1,416	5.9	316	1	0.3
39	f	5.4	Sr.	166	48	240,197	2,625	5.8	241	3	1.2
Average		4.7	1.38	162	40	177,911	1,917	6.3	238	5.2	2.5
<i>Group Wa</i>											
40	f	4.9	Soph.	124	31	119,522	3,334	17.0	527	19	3.8
41	f	5.4	Soph.	152	40	111,903	5,322	10.6	422	13	3.1
42	f	5.0	Jr.	165	46	279,409	3,162	22.4	1,032	9	0.9
43	m	4.0	Fr.	154	36	80,731	507	8.6	300	4	1.3
44	f	4.0	Fr.	124	59	323,366	4,016	13.4	791	27	3.5
45	f	5.2	Fr.	165	50	234,594	3,019	9.8	518	4	0.8
46	f	4.9	Fr.	178	29	90,314	1,526	17.9	520	14	2.7
47	f	3.6	Fr.	135	47	160,563	1,768	9.0	423	6	1.4
48	f	3.6	Fr.	118	43	275,225	5,401	17.7	760	6	0.8
49	m	4.6	Sr.	160	26	78,246	777	14.2	369	5	1.4
50	f	4.6	Soph.	131	52	223,883	1,759	9.6	501	7	1.4
51	f	5.1	Fr.	154	37	140,467	2,414	15.9	590	13	2.2
52	m	4.2	Fr.	168	30	71,482	1,017	14.9	448	4	0.9
53	f	4.6	Fr.	157	49	262,961	5,057	16.4	796	15	1.9
54	m	4.4	Soph.	116	37	106,514	1,373	12.1	447	13	2.9
55	f	5.2	Fr.	153	42	148,318	4,278	13.8	581	11	1.9
Average		4.6	1.81	147	41	169,219	2,796	13.96	564.6	11.3	1.9

group *Pa* were in training for so short a time that the results could not be used.

The two groups (*Pa* and *Wa*) were trained under as nearly identical conditions as was possible. This was done by having them meet in the same class for training purposes except during the first six sessions. During these practice periods all could not meet at the same time on account of too few machines, but at each practice period there were learners from both groups.

The practice periods, it will be recalled, were 55 minutes in length and the speed test periods, of five minutes each, were

TABLE VI

SHOWING P.E.'S OF GROUP DIFFERENCES BETWEEN THE AVERAGES, AND THE STANDARD DEVIATIONS OF THE DISTRIBUTIONS FOR TABLE V

	School marks	School ranks	Mental test scores	Total practice periods	Total letters written	Total errors made	Av. number letters per practice period at end	Final scores in letters per 5 minutes	Final score in errors per 5 minutes	Per cent. of error in final scores
Averages group <i>Pa</i> ...	4.74	1.38	161.8	40.0	177,911	1,917	6.3	237	5.2	2.5
Averages group <i>Wa</i> ...	4.58	1.56	147.1	40.9	169,218	2,795	13.9	564	11.3	1.9
Difference in averages for groups <i>Pa</i> & <i>Wa</i>...	.16	.18	14.7	.9	8,693	878	7.6	327	6.0	.6
P.E. of dif. in av. ....	.14	.21	4.5	3.01	18,823	364	.7	35	1.3	3.5
Standard deviations of distribution:										
<i>Wa</i>.....	.55	.86	18.5	9.06	81,435	1,598	3.8	184	6.2	.9
<i>Pa</i>.....	.55	.84	17.2	13.9	68,906	1,309	1.9	84	3.3	1.6

included in this time. The speed tests were not begun until March 13, 1923. This was two months and two days after the beginning of the experiment. Subjects were taken in at different times during the course of the experiment, and because of this some of the learners began the tests with less training than others did. This is shown to some extent by the difference in the number of practice periods for the various subjects.

In Table V it is shown that group *Wa* has a median of 41 with a range of from 26 to 59 practice periods of 55 minutes each. The P.E. of this distribution is 4.89, and the number of cases is 16. For group *Pa* there were 13 cases ranging in the number of practice periods from 17 to 56, a P.E. of the distribution of 9.63, and a median of 43.

Results and Discussion.—In Table V we present a general view of the materials and results of this experiment. Here we have

a statement of the nature of the various learners, the amount of time devoted to the work of learning, and the actual accomplishment for each learner.

This table shows that in school marks and in school rank group *Wa* has a slight advantage. In school marks the average difference is .16,¹ with a P.E. of .14. In school rank the average difference is .18 of a school year, with a P.E. of .21. Statisti-

TABLE VII

SHOWING THE P.E.'S OF GROUP DIFFERENCES BETWEEN THE AVERAGES, AND THE STANDARD DEVIATIONS OF THE DISTRIBUTIONS FOR TABLES VIII AND IX

Words—Speed Tests												
Tests	1	2	3	4	5	6	7	8	9	10	11	12
Averages group <i>Pa</i>	18.4	21.7	26.6	29.6	26.8	29.3	34.9	44.4	47.4	52.7	65.5	59.5
Averages group <i>Wa</i>	86.3	92.9	88.1	88.8	89.2	91.1	113.9	110.3	105.2	116.3	145.2	148.9
Dif. in averages for groups <i>Pa</i> and <i>Wa</i>	67.9	71.2	61.5	59.2	62.4	61.8	79.0	65.9	57.8	63.6	79.7	89.4
P.E. of dif. in av.	5.1	5.0	6.0	4.5	7.2	6.0	7.4	6.8	7.3	7.5	10.7	11.9
Standard deviations of distribution:												
<i>Pa</i>	8.4	8.0	6.9	8.6	7.8	9.9	10.0	11.4	14.9	14.8	9.7	14.2
<i>Wa</i>	34.2	27.1	28.0	22.3	34.4	27.8	35.0	31.1	31.1	33.5	41.0	44.9
Errors—Speed Tests												
Tests	1	2	3	4	5	6	7	8	9	10	11	12
Averages group <i>Pa</i>	7.9	7.0	7.4	7.0	5.4	5.9	5.7	7.0	6.6	5.5	7.1	6.1
Averages group <i>Wa</i>	12.0	14.7	10.9	12.7	12.4	12.3	8.9	10.9	12.3	8.9	9.8	11.7
Dif. in averages for groups <i>Pa</i> and <i>Wa</i>	4.1	7.7	3.5	5.7	7.0	6.4	3.3	3.9	5.7	3.4	2.7	5.6
P.E. of dif. in av. . . . .	.8	1.6	1.8	1.5	1.5	2.0	1.2	1.7	1.8	1.3	1.5	1.7
Standard deviations of distribution:												
<i>Pa</i>	2.9	3.3	5.6	3.3	2.5	1.9	3.4	4.1	3.5	3.2	4.5	3.9
<i>Wa</i>	3.4	8.2	6.0	5.5	7.4	9.8	5.0	7.4	7.6	5.1	4.0	5.6

cally these differences are unreliable, thus indicating that for these factors the groups are approximately equal.

In the same table the results of the mental tests (Otis Group Form A) show an average score of 161.8 for group *Pa*, while group *Wa* made an average of 147.1. This is a difference of 14.7 ± 4.47 . The standard deviation of the distribution for *Pa* is 18.5 and for *Wa* it is 17.15, with a median of 165 and 153.5, respectively. This difference is rather high and closely approximates the limit of reliability. Just why group *Wa* should be so much lower in the mental test scores cannot be explained since the subjects were assigned to their respective groups by a chance

¹ The unit in this case is $A=6$, $B=5$, $C=4$, $D=3$, with steps of equal value.

method. The test (Otis group) was the same for all and was administered to both groups together. The correlation, by the rank difference formula, of the scores in the mental tests with number of letters gained per practice period, as shown by the final test score for both groups, is minus $.36 \pm .16$.

In Table V we also see that group *Pa* practiced an average of 40.0 periods of 55 minutes each. *Wa* practiced 40.9 periods. This is a difference of $.9 \pm 3.01$. In the total number of letters written *Pa* made 177911.3 while *Wa* made 169218.6, thus showing a difference in favor of *Pa* of 8692.7 ± 18823 . In errors *Pa* made an average score of 1917.2 while *Wa* made 2795.6. The difference in average in this case is 878.4 ± 364.1 . Statistically these differences are all unreliable. They indicate that as far as the training of these two groups is concerned there is no certain difference, and if "practice makes perfect" in typewriting, as Hoke points out, then we should expect, under like conditions of training, that they would perform equally well in typing skill. A better measure of skill in manipulating a typewriter is shown by what the operator can accomplish when put to the test in such work.

In the final scores of the two groups, we have an average difference of 327.14 ± 34.83 letters per five minutes between the means of the two groups in favor of group *Wa*. Statistically this is a reliable difference and the difference is a large one, since the average for group *Pa* is 237.4 and that for group *Wa* is 564.6. It will be noted that the per cent. of error is also less for group *Wa* in this test.

The gain in letters per practice period is found by dividing the final test score by the number of practice periods. The column under the caption, "Av. number letters per practice period at end," gives this part of the data. Group *Pa* made an average score in letters per practice periods of 6.34, while *Wa* made 13.96. This is a difference of $7.62 \pm .72$, a very substantial difference, which shows, on the average, that *Wa* made more than two times the rate of gain, in words written, than was made by *Pa*.

In the actual number and the per cent. of errors made in the final test score the results are as follows: Group *Pa* averaged

5.23 errors per five minutes of writing, while group *Wa* averaged 11.25, a difference of 6.02 with a P.E. of 1.26. When these error records are converted into per cent. on the basis of the number of words written, we find that group *Pa* made an average per cent. of error in the last speed test of 2.53. Group *Wa* made in the same way a per cent of 1.93. This is a difference of .60, with a P.E. of the difference of 3.46. The first difference is

TABLE VIII

INDICATING THE NUMBER OF WORDS WRITTEN, THE NUMBER OF ERRORS MADE, AND THE PER CENT. OF ERROR AGAINST NUMBER OF WORDS WRITTEN FOR THE AVERAGE OF EACH OF THE FOUR COMPOSITE SPEED TEST SCORES

		<i>Group Pa</i>											
		Scores in speed tests (5 minutes)											
Subjects		1	2	3	4	5	6	7	8	9	10	11	12
27 W.....		15.0	22.0	36.0	36.0	.....	.....	.....	.....	.....	.....	.....	.....
E.....		10.0	7.0	5.0	5.0	.....	.....	.....	.....	.....	.....	.....	.....
28 W.....		28.3	.....	31.5	40.0	37.0	.....	45.0	53.0	73.0	82.5	80.5	66.0
E.....		5.3	.....	10.0	9.5	9.0	.....	11.0	15.0	12.5	11.5	12.0	15.0
29 W.....		12.0	17.0	23.0	.....	21.0	28.0	31.0	29.5	33.3	38.0	49.0	45.0
E.....		8.0	5.0	1.0	.....	3.5	4.5	4.5	3.0	3.3	0.0	0.0	3.5
30 W.....		17.0	9.0	20.0	.....	13.0	15.5	19.5	27.0	.....	30.0	.....	.....
E.....		8.0	3.0	2.5	.....	3.0	4.5	1.0	4.0	.....	4.5	.....	.....
31 W.....		31.0	33.0	.....	34.5	38.0	46.6	45.0	52.5	55.3	52.5	69.6	68.3
E.....		5.5	8.0	.....	2.0	3.0	4.6	2.5	4.0	2.8	2.5	3.5	2.6
32 W.....		8.5	17.5	.....	20.0	20.0	26.0	27.3	.....	.....	.....	.....	.....
E.....		4.5	8.5	.....	8.0	5.0	7.0	3.0	.....	.....	.....	.....	.....
33 W.....		19.5	27.0	.....	27.5	21.0	24.0	.....	.....	.....	.....	.....	.....
E.....		14.0	7.0	.....	4.0	6.0	7.0	.....	.....	.....	.....	.....	.....
34 W.....		14.0	19.0	15.5	17.0	26.0	24.0	25.0	32.0	39.6	47.0	58.0	44.0
E.....		10.3	8.0	8.0	12.0	6.5	7.0	6.0	6.0	6.0	11.0	15.0	6.5
35 W.....		36.0	35.5	33.0	37.5	36.0	41.0	50.0	58.0	60.0	72.0	69.0	75.0
E.....		12.0	14.0	21.0	13.0	10.0	9.0	10.0	10.5	8.5	7.5	10.0	9.6
36 W.....		12.6	13.0	24.0	33.3	24.0	25.0	44.5	54.6	.....	55.0	72.5	74.5
E.....		6.6	5.0	3.5	6.6	7.5	8.0	7.0	3.3	.....	5.0	8.0	6.0
37 W.....		8.0	18.5	.....	16.0	20.0	19.0	27.0	.....	23.0	41.0	.....	39.5
E.....		4.0	2.5	.....	4.0	3.5	2.0	4.0	.....	2.0	3.0	.....	6.5
38 W.....		23.5	32.5	34.6	39.0	29.0	45.0	43.0	51.3	52.0	60.0	70.5	75.0
E.....		7.5	11.5	9.3	8.0	6.0	6.5	10.0	11.0	9.0	4.0	2.0	2.5
39 W.....		14.0	21.0	22.0	24.5	26.5	28.0	27.5	41.6	43.0	39.0	55.0	48.6
E.....		8.0	4.0	6.0	4.5	2.0	5.0	2.5	3.6	9.0	6.0	6.0	3.0
Av. W.....		18.4	21.7	26.6	29.6	26.8	29.3	34.9	44.4	47.4	52.7	65.5	59.5
E.....		7.9	7.0	7.4	7.0	5.4	5.9	5.6	7.0	6.6	5.5	7.1	6.1
Per cent. error for scores		4.3	3.2	2.8	2.4	2.0	1.7	1.6	1.6	1.4	1.0	1.0	1.0

statistically reliable, but the other is not. This is what one should expect, since the number of errors depends in a great measure upon the number of chances one has to make them. It is evident that the more words that one writes the greater the chances he has to increase the number of errors, while at the same time the per cent. of error might be decreased. This was the case for the two groups in this experiment. Group *Pa* made fewer errors on the average by 6.02 per five minutes of practice than *Wa* made at the same time; but when the number of errors is compared

with the number of letters written at the same time the advantage is with group *Wa* by a difference in per cent. of error of 1.93.

Speed Tests.—In Tables VII, VIII, and IX, as well as in Figures II and III, are presented the results of the speed tests. It is in these that we get the best view of what the accomplishment was for the learners of the two groups. A test was conducted each day, beginning March 13th, for a period of five minutes. The rest of the 55 minutes was devoted to practice. Each column in these tables represents the average of four consecutive tests for each student in words written and errors made, so that the twelve columns of the table represent 48 test periods.

In column 1 of Table VIII we see that group *Pa* made an average score of 18.4 words per five minutes. In this same set of tests group *Wa* averaged 86.3 words. This is a difference of 67.9 ± 5.057 , a difference that is very marked. If we look at the average score of the last set of tests represented in the same tables, we find a difference of 89.4 ± 11.88 words.

During the period from January 10th to March 13th no tests were given. This was because the learners of group *Pa* had not used enough of the keyboard during their practice to make comparable in any way the results of such a test. To have started testing at the first would have introduced the larger unit exercise material into the daily work of group *Pa*. This would have complicated the two methods to the extent of making it impossible to determine what was responsible for the results obtained. This group had not had training on the complete keyboard at the time the tests were started. This, of course, is due to the nature of the material presented for practice. It should be remembered that the two groups began training at the same time and under the same conditions of instruction.

Figure II presents the relation of the two groups throughout the entire period of training after the tests were first given. According to these curves, the difference between the two groups is decidedly constant for each set of tests. The difference at any point in the learning is great and the results presented in Table VII show that these differences are within the limits of being statistically reliable. In many of these measures the P.E. of the differ-

ences is less than one-tenth of the differences between the average scores. None is as great as one-fifth of the difference.

In the Tables VII, VIII, IX, we also find the results in errors. These are represented in graphic form in Figure III. Group *Pa* is very much lower in the number of errors made. For these

TABLE IX

INDICATING THE NUMBER OF WORDS WRITTEN, THE NUMBER OF ERRORS MADE, AND THE PER CENT. OF ERROR AGAINST NUMBER OF WORDS WRITTEN FOR THE AVERAGE OF EACH OF THE FOUR COMPOSITE SPEED TEST SCORES

		<i>Group Wa</i>											
		Scores in speed tests (5 minutes)											
Subjects		1	2	3	4	5	6	7	8	9	10	11	12
40 W	.....	95.0	97.0	.....	110.0	.....	117.0	.....	.....	.....	.....	.....	.....
E	.....	24.4	22.5	.....	19.0	.....	32.0	.....	.....	.....	.....	.....	.....
41 W	.....	54.0	61.5	.....	63.0	63.0	66.5	74.0	73.8	80.0	87.0	94.0	98.3
E	.....	40.0	29.5	.....	16.0	20.0	24.5	18.5	19.3	19.0	16.5	9.0	14.6
42 W	.....	185.6	166.3	161.0	.....	180.0	.....	176.0	214.5	.....	.....	.....	.....
E	.....	13.0	8.3	11.0	.....	0.0	.....	7.0	10.5	.....	.....	.....	.....
43 W	.....	46.0	49.6	52.0	42.5	52.0	44.0	62.0	58.5	53.5	71.0	.....	.....
E	.....	4.0	1.3	2.5	4.5	4.0	3.0	1.5	6.0	3.0	2.0	.....	.....
44 W	.....	113.0	124.5	107.0	114.0	115.0	122.3	123.3	131.0	147.8	141.8	205.0	196.5
E	.....	12.0	16.5	18.6	18.6	10.0	18.6	8.0	6.0	14.0	10.3	8.0	21.5
45 W	.....	72.0	83.0	65.0	83.0	88.0	80.0	96.6	86.0	93.0	110.5	123.3	126.6
E	.....	10.0	20.0	9.0	14.3	10.0	6.0	6.3	16.0	10.3	7.0	10.0	5.6
46 W	.....	92.0	98.0	.....	114.0	100.0	.....	.....	.....	.....	.....	.....	.....
E	.....	11.0	12.0	.....	14.0	16.0	.....	.....	.....	.....	.....	.....	.....
47 W	.....	64.0	73.5	.....	.....	.....	70.0	63.0	76.0	82.5	83.0	90.0	93.0
E	.....	4.0	11.5	.....	.....	.....	3.6	6.5	4.0	3.5	4.5	8.6	5.6
48 W	.....	43.0	76.0	74.0	86.0	84.0	.....	106.5	148.0	141.3	177.0	.....	166.6
E	.....	7.3	20.0	15.0	10.0	8.0	.....	10.0	7.0	10.3	11.0	.....	7.3
49 W	.....	82.0	89.0	80.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
E	.....	6.0	5.0	6.0	.....	.....	.....	.....	.....	.....	.....	.....	.....
50 W	.....	87.0	90.6	81.5	89.3	.....	.....	.....	.....	.....	.....	.....	.....
E	.....	3.0	5.3	5.5	5.8	.....	.....	.....	.....	.....	.....	.....	.....
51 W	.....	83.0	80.0	87.5	89.0	98.0	101.0	117.0	.....	104.0	113.0	.....	.....
E	.....	6.0	10.3	5.5	9.0	11.0	10.0	11.0	.....	12.0	7.0	.....	.....
52 W	.....	.....	86.0	.....	72.5	80.0	107.0	75.0	82.5	91.0	93.5	120.0	.....
E	.....	.....	3.5	.....	4.5	2.0	1.0	3.0	3.5	.....	3.0	3.0	.....
53 W	.....	106.0	119.0	108.0	126.3	28.0	141.0	216.0	147.0	162.5	174.5	254.0	221.5
E	.....	31.0	22.3	23.0	20.3	30.0	21.0	17.0	29.0	31.5	19.0	13.0	16.5
54 W	.....	86.0	.....	80.0	77.0	.....	68.0	.....	100.0	98.5	109.0	.....	.....
E	.....	8.5	.....	10.0	11.0	.....	4.0	.....	10.0	5.5	7.0	.....	.....
55 W	.....	.....	90.0	73.0	89.0	93.0	85.0	143.0	106.0	103.0	119.0	130.0	141.0
E	.....	.....	22.5	14.0	19.0	15.0	11.0	9.0	9.0	14.0	11.0	17.0	11.0
Av.	.....	86.3	92.9	88.1	88.8	89.2	91.1	113.9	110.3	115.8	116.3	145.2	148.9
E.	.....	12.0	14.7	10.9	12.7	12.4	12.3	8.9	10.9	11.9	8.9	9.8	11.7
Per cent. error for scores		1.4	1.6	1.2	1.4	1.4	1.4	.8	1.0	1.0	.8	.7	.8

the differences are not statistically reliable, as the results show. Generally this becomes more and more the case as the experiment progresses.

If we look again at Figure III it will be observed that in per cent. of error, on the basis of the number of words written, group *Wa* is far superior at the first set of tests, with a per cent. of 1.4 as against 4.3 for *Pa*. As the work progresses the two groups become more and more alike until in the end the difference is

represented by 1 per cent. of error for group *Pa* and .8 per cent. for group *Wa*. This should be expected, because when the tests began group *Pa* had exercised only on a portion of the keyboard. After the beginning of the testing this group had five minutes of practice per day on complete composition material because the materials used in the tests were business letters.

The training of the learners of group *Pa* from that time included five minutes of work per day on the more *comprehensive unit* material. This seems to have had the effect of speeding up the relative efficiency of performance. It should be remembered that these two groups began at the same time, for both practice and in speed testing. At the beginning of the training they must have been more nearly equal in typing ability than at any time thereafter,¹ the subjects being all without previous experience in the use of a typewriter. This difference is represented by an average score in words written (per five minutes) of 18.4 for group *Pa*, and of 86.3 for group *Wa*. The experiment was continued through a second nine weeks and the relative positions represented in this difference remain nearly constant. What is the explanation of such results? This will be discussed at a later point.

It should be kept in mind that these two groups were under practically identical conditions of training except for the kind of exercise material used in the practice work. The results of this treatment are represented by the general shape of the two error curves (Figure III). For the most part, when there is a rise in one of these curves there is a corresponding rise in the other, and when there is a drop in one there is also a drop in the other. When the learners were urged to speed the number of errors increased. If we compare the error curves with the curves representing the number of words written, we see that, generally, when the words increase the errors also increase. This is not true for the per cent. of errors; when the speed is increased the per cent. of

¹ It is unfortunate that a measure of the learners was not taken at the start. The fact that none had had any previous experience in the use of a typing machine seemed, at the time, sufficient to establish equality in the learning of this skill.

errors decreases or tends to remain constant. The results in Table VIII and in Table IX show that there was a gradual rise in the number of words written and a gradual decrease in the per cent. of errors as the experiment progressed through to the end.

TABLE X

SHOWING THE NUMBER OF TIMES EACH LETTER WAS STRUCK, AND THE ERRORS MADE FOR BOTH PRACTICE AND SPEED TEST MATERIAL OF GROUP Pa AND GROUP Wa

Alphabet	Group Pa				Group Wa			
	Total number of letters	Average number letters per student	Total errors in speed tests	Per cent. error of total letters against errors in speed tests raised 100 times	Total number of letters	Average number letters per student	Total errors in speed tests	Per cent. error of total letters against errors in speed tests raised 100 times
A	295,834	22,756	42	.01	257,498	16,093	140	.55
B	486	37	30	.47	51,937	3,246	107	2.16
C	21,049	1,619	48	1.92	94,668	5,916	98	1.03
D	154,291	11,099	22	.15	98,300	6,144	88	.90
E	204,618	15,740	78	.38	358,444	22,403	233	.65
F	143,829	11,064	15	.11	19,769	1,236	45	2.26
G	5,952	389	29	5.67	31,619	1,976	81	2.56
H	4,165	320	68	16.25	146,278	9,142	89	2.56
I	109,331	8,410	96	.88	161,097	10,069	163	1.01
J	107,489	8,268	2	.88	6,104	382	12	2.09
K	142,797	10,984	8	.56	12,358	772	19	1.56
L	321,660	24,743	37	.11	150,040	9,378	104	.69
M	20,460	1,574	71	3.49	76,549	4,784	87	1.13
N	2,458	189	75	30.69	199,404	12,463	163	.82
O	65,022	5,002	87	1.34	253,931	15,871	145	.57
P	52,496	4,038	33	.61	34,521	2,158	63	1.81
Q	19,711	1,516	3	.13	2,971	186	9	3.23
R	169,494	13,038	80	.48	141,057	834	159	11.87
S	271,633	20,895	32	.12	166,209	10,288	136	.83
T	3,133	233	117	38.63	246,055	15,378	155	.63
U	116,635	8,972	43	.37	93,782	5,861	82	.87
V	18,785	1,445	15	.83	25,089	1,568	43	1.72
W	50,535	3,886	27	.54	49,532	3,096	66	1.32
X	5,390	415	3	.48	8,787	549	9	.09
Y	834	64	52	62.50	74,087	4,630	88	1.19
Z	4,813	370	0	0.00	2,803	175	1	.57
Average	88,923	6,810	43	6.06	106,265	6,332	92	1.68

Tables VIII and IX show results that might be interpreted as great irregularity on the part of the learners, because there are many places in the test scores represented by dashes. On closer view it will be observed that most of such indications are for those that had discontinued the work. On the part of the subjects in

group *Wa* there was a stronger tendency to discontinue. Of this group five discontinued at the eleventh set of tests as against three of group *Pa*. This was probably due to the fact that some had reached the point where they could write rather effectively, with scores in a few cases of as much as 40 words per minute. None of those of group *Pa* was writing as many as 17 words per minute at this point.

The Alphabet.—What is the relation between the number of times a letter is struck and the accuracy with which it is written

TABLE XI

SHOWING THE P.E. OF GROUP DIFFERENCES BETWEEN THE AVERAGES, AND THE STANDARD DEVIATIONS OF THE DISTRIBUTIONS FOR TABLE X

	Total number of letters	Average number of letters per student	Total errors in speed tests	Per cent. error of total letters against errors in speed tests raised 100 times
Averages for group <i>Pa</i>	88,923	6,810	43	6.06
Averages for group <i>Wa</i>	106,265	6,332	92	1.68
Dif. in av. for groups <i>Pa</i> and <i>Wa</i> ...	17,342	478	49	4.38
P.E. of dif. in av.....	18,811	1,259	8.65	1.96
Standard deviations of distributions:				
<i>Pa</i>	106,400	7,418	30.65	14.65
<i>Wa</i>	94,200	5,964	57.54	2.15

at the end of the learning period? It seems to be pretty well implied, by the nature of the material used for practice, that *repetition* is the most important condition of learning to manipulate a typewriter. And by the way the symbols are combined in the exercise material in common use, it would seem that machine placement of letters in terms of the fitness of the figures is all that need be taken into account in determining what the exercise should be. All texts that are available to the writer, except that published by Depew in 1921, provide meaningless exercise material for the early part of the training. Repetition seems to be the watchword in all that is proposed for learning this skill.

Table X presents results for the total number of times each letter was struck, the average number of times each letter was struck by each learner, the total errors for each letter of the alphabet in the speed tests, and the per cent. of errors in the speed

tests figured on the basis of the number of times each letter was used in all exercises.

If we compare the results of Table X with those of Table VIII it will be seen that while group *Pa* wrote more letters than did group *Wa*, the average per cent. of error for the latter group was much less, being 1.68 as contrasted with 6.062 for group *Pa*. This is a difference of 4.34 ± 1.958 . This difference is not statistically reliable, but it seems not to favor the "practice makes perfect" doctrine for typewriting (14, p. 21). When we com-

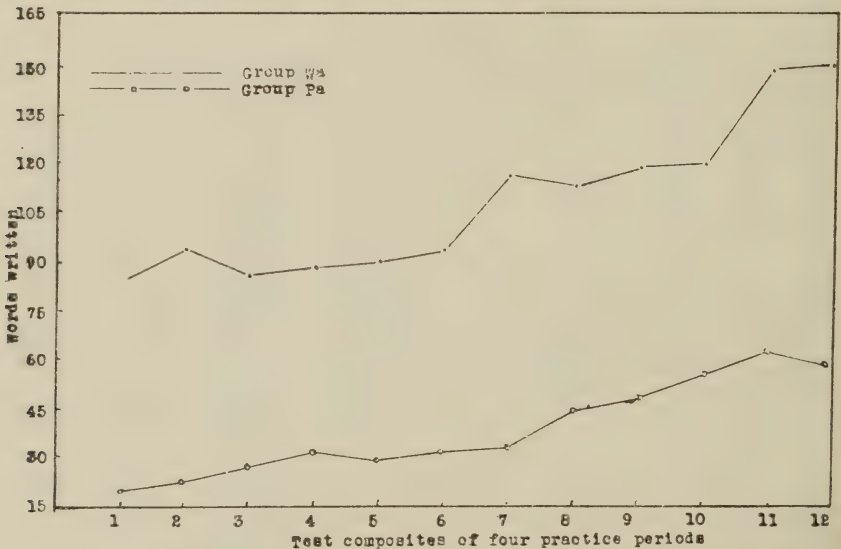


FIGURE II. Showing curves of acquisition in composites of four tests, conducted each day during the second five minutes of a 55-minute practice period.

pare the amount of practice for each letter with the per cent. of errors made in the speed tests we get a coefficient of correlation of $.70 \pm .07$ for group *Wa* and $.60 \pm .08$ for group *Pa*. Hoke, with different composition material, found a coefficient of ".924 with a P.E. of .021" (14, p. 21). He used the products-moment formula while, in this study, the rank difference was used in calculation, and the coefficient was converted to r by the use of the table given by the Scott Company Laboratory (29, p. 128).

If repetition is so important, why should the material used in practice not conform more nearly to the materials used after the

learning is completed? Table X shows that the letter *t* is ranked twenty-third in the number of times that it was used by *Pa* in practice, while with group *Wa* it is ranked fourth. Again, the letter *n* is ranked twenty-fourth for group *Pa* and fifth for group *Wa*. The letters *r*, *f*, *h*, and others, are similarly neglected by group *Pa*, but not to the extent indicated for *t* and *n*. These results seem to show that more attention should be given to the

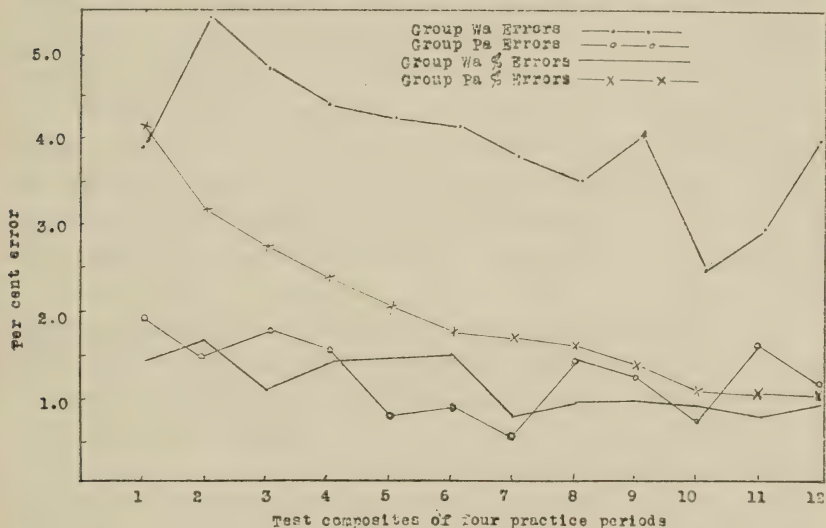


FIGURE III. Showing curves of the number and per cent. of errors in composites of four tests conducted as in Figure II above.

providing of exercise material that will center the practice on the letters that are used most frequently in the composition material of finished typists.

Are we to conclude, then, that mere repetition is the factor responsible for the accomplishment of skill in typewriting? The results shown in Table X seem to support such a view. Frequent repetition of the various letters produces a higher number of errors, but this is because such a condition provides more opportunity to make the incorrect response. But when the errors are represented by per cent. (of the practice in learning) it is found that the greater the number of repetitions the less the tendency is to respond incorrectly. But does this show that it is the repetition of the response that produces the change?

IV. DISCUSSIONS AND CONCLUSIONS

Problem.—The question of the kind of material to use for practice in the learning of typewriting has not been raised by any of the investigations of the acquirement of this skill. All such studies have been concerned with the nature of learning as shown by curves and other representations of what the factors are that condition learning, as it is commonly taught. In cases where learning was accomplished by the sight method the material was of the *complete composition* kind; in those employing the touch method, the *meaningless units* were used. There has been no prior attempt to compare the relative effectiveness of these two kinds of material as means of attaining results in the acquirement of this skill.

Since 1921 there has been a decided tendency on the part of makers of texts on the teaching of typewriting to get away from the use of meaningless letter combinations as exercise material; and at present some of the late ones are making use of complete sentences as early as the third exercise.

Subjects.—The method of selecting and assigning the learners to their groups in the first experiment of this study did not strictly conform to the best methods in making a scientific investigation. The same criticism applies to the collecting and recording of the data. In both these matters all the material available was presented. Notwithstanding these defects, the results show such wide differences in typing skill for the two groups that the irregularities cannot explain them.

The subjects of group *P*, who were trained by means of the smaller units, and those of group *W*, trained by the more comprehensive units, show no difference in fitness for learning that could influence the results very materially, notwithstanding the irregularity of selection. In the amount of time spent in practice, the difference is that of the first eleven weeks. During this time group *W* was not training at all. Both groups trained an equal amount of time after this. That is, group *P* was trained

eleven weeks longer, during the school year of thirty-six weeks, than was group *W*. This should be kept in mind when comparing the results of these two groups.

The subjects of group *Pa* and of group *Wa* were selected by a chance method. At the time of starting the experiment they all affirmed that they were without previous experience in the manipulation of a typewriter. In the school marks, school rank, and mentality there is no difference between the two groups that is statistically reliable. The mental tests show a slight advantage on the part of group *Pa*.

In both experiments, then, the compared groups were approximately equal as far as the demands of this study are concerned. The differences that are shown are about as small as one could expect for groups selected by any chance method.

Training.—Groups *P* and *W* were taught alike by the same teacher throughout, except for the kind of practice material used in training and such other minor matters as were incidental to the two methods used. Group *P* used the material presented in the text by J. W. Mosher published in 1903. Group *W* used complete composition material. Both used the same practice material after the first speed test. The groups were not taught in separate classes, but were mingled together in both the speed tests and the practice periods, thus making the work of training practically identical. This was true only after group *W* began practice work like that made use of for group *P*, which was eleven weeks after group *P* had started.

The periods of training for *P* and for *W* were 40 minutes per day, five days per week, throughout the school year of thirty-six weeks.

Group *Pa* and group *Wa* were also trained in common except for the first few periods of practice. They thus received as nearly the same kind of instruction and treatment, after the first few days, as students in the same class get under the same teacher, except in the nature of the practice material used. Group *Pa* used the text by Ross published in 1914, while group *Wa* was trained throughout by means of the material found in the business letters presented by C. E. Birch in his text of 1920.

Results.—The results show that group *W* after training for five weeks made a better record than was made by group *P* even though the latter had been training during the same period that group *W* had been trained, as well as during eleven additional weeks next preceding the five weeks. The P.E. of the difference is less than one ninth this difference. It should be remembered that the scoring method might be questioned, although it is not seen how a composite score of words and errors could operate to the advantage of either group.

From this point on to the second speed test we see that group *P* makes very rapid progress; so much so that when the second speed test is given (three weeks later) the difference between the two groups is not within the limits of reliability. This rapid rise in the curve has not been accounted for, but it is probably a direct result of the *P* group getting away from the effects of negative transfer or interference. From the first test through to the end, the average differences, while not statistically reliable, are constant and favorable to group *W*. This is a rather strong indication that the differences during this time are more than accidental. These differences, although only slight, make it appear that there were eleven weeks of time wasted in the training of group *P*, due to the use of meaningless units as practice material.

Another peculiar aspect of the results of the tests is that after the first measure was taken the relative difference between the two groups remains almost constant to the end. Since the only change that took place at this point in the learning was that of giving group *P* five minutes of training each practice period on the comprehensive materials used in the tests themselves, it seems that this kind of material was responsible for the difference remaining practically the same to the end. Some such effect was somewhat anticipated, so the test periods were made no longer than five minutes. It should be noted further that in both experiments the results show that about the time the two opposing groups, in both experiments, began work on complete composition material the difference between them remained practically constant.

In the second experiment *Pa* and *Wa* began training at the same time (it should be recalled that this was not the case for

P and *W*), and were trained under as nearly identical conditions as seemed possible for schoolroom conditions of experimentation, except for the kind of practice material used. In this group *Pa* was trained by means of the meaningless unit, while *Wa* was trained by means of that found in business letters.

The differences could not have been in the degrees of motive induced in teaching, since the results of the second experiment show that the difference is equally as great as when the two groups were training at different times. In the last experiment the two groups were together all the time except for the first few practice periods.

The results indicate plainly that the greater the number of repetitions the greater the per cent. of accuracy. This is true not only on the whole, but there are very few exceptions to this rule when each letter is considered separately.

It is evident that group *W* and group *Wa* had a decided advantage over group *P* and group *Pa* in acquiring skill in the manipulation of a typewriter and that this advantage for these more successful groups was probably due to the fact that these *W* groups were trained by means of the more comprehensive material as practice matter.

If to repeat an act increases the chances that it will be performed again, is it not sensible to expect that the best results will be obtained if the repeated acts are as nearly as possible identical with those in the skill to be performed subsequently? This question suggests an explanation of why the complete composition material is better than the meaningless jargon, or smaller unit material, so widely employed in teaching typewriting.

We may suggest here that *possibly it is not the repeating of the act, as such, that is so important in the producing of the change called learning*, because the letters written by group *Pa* and by group *Wa* are statistically equal, *but group Wa made more than two times as good a record as group Pa did in the speed test that shows the least difference between these two groups.* The scores in this test are 105.2 words per five minutes for group *Wa* and 47.4 for group *Pa*. The difference is 57.8 ± 7.3 .

The real problem in learning is to determine what the factors

are that are responsible for retaining the mechanism that is necessary for the correct response, and what it is that makes inactive the mechanism responsible for the incorrect response. Thorndike has rightly emphasized his "law of effect" (33, p. 71) in learning, but he has failed to make clear by what neural conditions it may be done. Woodworth has recently emphasized what he calls "the law of combination," apparently recognizing the need of getting away from mere frequency and recency in learning as the supposed sole determining factors. MacDougall (19, p. 194) takes issue with the "effects" theory on the grounds of its being "a clear case of effect preceding the cause."

Peterson has shown experimentally (23) that frequency and recency factors are not as important in establishing mechanisms used in response as has been made out for them; and that learning goes on even in cases where frequency and recency factors go against it (22). Similar results have more recently been obtained by Kuo (18). Concerning recency and frequency among other factors that are responsible for learning, Peterson says: "Elimination of random acts not favoring the dominant determining tendency seems to be brought about somehow by interference through conflict of different interacting processes. Determining tendencies and purposes are themselves but general directions in behavior effected by the larger consistency of the environment and by the inner metabolic processes" (24, p. 384). In discussing how our control over immediate conditions is brought about, he says further: "We overrule them because they are inconsistent with the larger conditions that have shaped our behavior trends, both those that are innate and those that are acquired (24, p. 386), . . . but I wish to emphasize the ability or the tendency to respond to comprehensive and complex situations as against the response to immediate stimuli" (24, p. 389). He is discussing the nature of intelligence in this last quotation, but states that "such a view relates intelligence to learning, which certainly includes reconstructive aspects" (24, p. 389).

The results of this study seem to support the "laws" of Thorndike and of Woodworth which attempt to go beyond mere frequency-recency factors, and they agree with the experiments of

Peterson and of Kuo just cited. In the interpretation of our results the views expressed by Peterson are most helpful. The larger and more comprehensive units produced the most rapid learning, probably because they are more consistent among themselves and more thoroughly in harmony with the determining tendencies of the learner.

Our experiment undoubtedly suggests means of greatly improving current methods of instruction in typewriting, to say nothing of such other skills as stenography, handwriting, piano playing, etc., each of which needs special experimental investigation.

This problem grew out of the practical experience of the writer while serving as superintendent of a small city school system. At the time of opening school, in September, 1918, there was no thought of submitting the methods of teaching typewriting to experimentation. The discussions of methods of teaching, in the regular meetings of the teachers, suggested that possibly a shift from the "A B C" method of teaching typewriting to that of larger units would prove beneficial, as had such a shift in the teaching of reading. These accumulating circumstances account for the irregularity in selecting the subjects of the first experiment as well as for the incompleteness of keeping records of results for all the subjects, since only the records of the teacher in charge were kept during the first few weeks of school.

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